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ABSTRACT

This paper describes a project which focused primarily on developing a method for qualitatively assessing and describing curiosity/inquiry styles in individual children. A class of "puzzling-phenomenon" tasks for idiographic assessment of scientific curiosity/inquiry was developed and individually administered to five rural and five urban primary-grade children, using an adaptive-facilitative clinical interview technique. These tasks were aimed at eliciting surprise, puzzlement, manipulative curiosity and inquiry, while minimizing inhibition of response due to the strangeness of the puzzling phenomena. All verbal and other sonic events were tape-recorded and later transcribed stenographically, including descriptions of tone of voice. Non-verbal behavior was hand-recorded by the interviewer and an accompanying observer. The sonic transcript and the non-verbal record were then combined into a single synchronous protocol which was analyzed on ten idiographic personality qualities related to curiosity and inquiry. Results indicated varying consistencies in personality qualities elicited by different tasks, and demonstrated specific values of tasks. Individually tailored facilitation of tasks, based on study of protocols, was successful in enhancing inquiry qualities. Results of the descriptive analyses were compared with observations of the same children in small-group classroom inquiry situations and with teacher perceptions of children. (Author/JMB)

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Assessing and Facilitating Manipulative Curiosity and Experimental Inquiry in Young Children

(EVA, SMP)

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ABSTRACT

A class of "puzzling-phenomenon" tasks for idiographic assessment of scientific curiosity/inquiry was individually administered to five rural and five urban primary-grade children, using an adaptive-facilitative clinical interview technique. Detailed protocols were analyzed on ten idiographic personality qualities related to curiosity and inquiry.

Results indicated varying consistencies in qualities elicited by different tasks, and demonstrated specific values of tasks. Individually tailored facilitation of tasks, based on study of protocols, was successful in enhancing inquiry qualities.

Results of the descriptive analysis were compared with observations of the same children in small-group classroom inquiry situations, and with teacher perceptions of children.

Paper presented at Annual Conference of the American Educational Research Association, New York City, April 5, 1977.

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SUMMARY

This paper describes the following innovations: (1) A general method for stimulating manipulative curiosity in primary-school children, with several well-characterized exemplars of the method. Each exemplar centres on a puzzling phenomenon, with simple apparatus which the child is encouraged to manipulate. (2) A method for qualitative idiographic assessment of individual manipulative curiosity and inquiry style displayed in response to the puzzling phenomena. (3) Techniques for facilitating intrinsically motivated experimental inquiry as continuation of manipulative curiosity, and for developing individual inquiry based on a study of the assessment results in (2).

(a) Objectives.

The project objectives were:

1. To develop a set of situational tasks for the clinical, idiographic assessment of individual styles of manipulative curiosity and experimental inquiry.

2. To use these tasks to explore and develop the "inquiry climate" that exists between child and interviewer.

3. To compare the idiographic assessment of the individual's curiosity and experimental inquiry in the one-to-one child-interviewer situation, with the child's inquiry behaviour in the classroom.

(b) Perspective.

There are few methods available for the systematic assessment of personal styles of experimental inquiry.

An assumption of the study was that experimental inquiry, in children in the primary grades, arises out of manipulative curiosity. Manipulative curiosity is a normal expression of intrinsic motivation for learning. Intrinsically motivated inquiry, it was assumed, could be initiated

when a puzzling phenomenon elicited manipulative curiosity and play. In addition to the importance of undirected play, a further assumption was that the inquiry motivation of children in the primary grades can be directed toward verbal understanding, at least in the case of relatively simple phenomena. The child's inquiry process can therefore benefit when the child is led to form and test hypotheses, or pre-hypotheses such as guesses, hunches, and claims to understanding. Children's tendencies and abilities in the logical testing of their own hypotheses are therefore suitable foci for study and pedagogy.

The puzzling phenomenon, as such, creates disequilibrium in a Piagetian sense. Puzzling phenomena stimulate children's inquiry. Piagetian workers have used the "clinical method" to study children's inquiry under adult-directed conditions, aiming toward developmental generalizations. However, the clinical method also finds application in idiographic studies. The clinical method is useful for getting at underlying factors when the child fails to display surprise and curiosity or fails to inquire. It is useful for facilitating inquiry by indirect means.

(c) Methods and techniques.

(1) Five task situations, each based on a different puzzling phenomenon, were developed, tested and evaluated. In addition to these intensively studied tasks, two task situations, based on simpler phenomena, were developed as warm-up tasks for inhibited children.

(2) A skeleton structure of eight basic steps was developed for use in all five tasks. The aim in developing these basic task elements was to elicit surprise, puzzlement, manipulative curiosity and inquiry, while minimizing inhibition of response due to the strangeness of the puzzling phenomena. The remaining part of the task procedure was unstructured and open-ended. Thus the course that the task situation followed was adapted to the child's responses, with the aim of eliciting idiosyncratic qualities of curiosity and inquiry response.

(3) Records of each protocol were taken as follows. All verbal and other sonic events were tape-recorded and later transcribed stenographically, including descriptions of tone of voice. Non-verbal behaviour was hand-recorded by the interviewer and an accompanying observer. The sonic transcript and the non-verbal record were combined into a single synchronous protocol for qualitative analysis.

(4) Protocols were qualitatively analyzed as follows. Ten idiographic personality qualities were conceptualized and developed empirically. They included **six** qualities considered of central importance to the study:

Surprise, puzzlement and wonder (SPW)

Intrinsically motivated manipulative curiosity (IMMCur)

Ideation about causes or conditions of the phenomena (Id)

Experimentalism (Exp)

Objectivity/Bias (Obj)

Reasoning (Reas)

They also included four more general qualities assumed to modify or influence the qualities of central significance. The qualities were: manner toward the interviewer; concentratedness; self-confidence and autonomy; and keenness of observation. Protocols were coded on the ten idiographic qualities. Since protocols differed greatly due to the adaptive course of the task, a summary of each protocol was first prepared. Then a summary description of the responses that had been coded under each of the six centrally important idiographic headings was derived from the protocol. Thus each of the fifty protocols (five tasks for each of ten children) generated six idiographic notes, one for each of SPW, IMMCur, Id, Exp, Obj, and Reas. These notes constituted the main descriptive data of the study.

(5) From a study of the descriptive data, each of the five main tasks was evaluated as a means for reliably assessing the centrally important curiosity/inquiry qualities.

(6) A summary statement of the inquiry style of each child was assembled from the descriptive data.

(7) The six centrally important idiographic qualities described for each child on each task, and the descriptive summary for each child were validated by the following methods.

(i) Each child was studied in the classroom in two or more small-group inquiry situations. Complete records were kept and analyzed qualitatively. The resulting descriptions were compared with those derived from the clinical interviews.

(ii) The idiographic descriptions derived from clinical interviews, with child identity and sex deleted, were given to the children's teachers. The teachers were asked to study the descriptions and think of how each pupil in the study resembled or differed from these descriptions. The teachers were then interviewed on their conclusions, and the interview protocols were coded and analyzed to determine how closely the idiographic qualities described for each child resembled teacher perceptions of the child's personality and inquiry qualities in the classroom.

(d) Data source.

Two samples of five children were randomly selected, one from an "advanced" private metropolitan school and one from a small rural school. All ten children were in Grade 1 or Grade 2. All ten children were given all five main tasks, and several in the rural school were also given warm-up tasks.

(e) Results and conclusions.

The puzzling phenomenon situation was found to be an unusually effective way of eliciting intrinsically motivated manipulative curiosity and experimental inquiry. In so doing, the task situations elicited personality qualities, some consistently and others less so. The degree of consistency differed among different children. With very few exceptions, however, the summary idiographic description of the child's inquiry style applied to all five main tasks.

The unique value of the puzzling-phenomenon situations appears to be their potential for eliciting a depth of response, indicative of the child's deeper response tendencies to material problems, and an intensity of interest and creative problem-finding and problem-solving not typically elicited by personality tests. The word "potential" needs emphasis, since, as has been shown above, some children remained relatively inhibited when the phenomenon was displayed.

In the course of administering the five main tasks, positive development was obtained in the idiographic qualities of manner toward interviewer, self-confidence and autonomy, manipulative curiosity, and experimentalism, in most instances where these qualities were judged deficient at the start.

Comparison of inquiry qualities derived from clinical interviews with classroom inquiry observations of the individual yielded varying results. In some cases, idiographic qualities were consistent in the two kinds of situation, in others, not so. In many of the discrepant cases, plausible explanations of the differences in behaviour were evident from a study of the very extensive records of the events. Individual tailoring of classroom inquiry topics and conditions resulted in many instances of strong development in inquiry behaviour.

Analysis of teacher interviews, not yet complete, indicates considerable agreement between teacher perceptions and idiographic qualities elicited in the clinical interview task situations.

(f) Educational and/or scientific importance of the study.

Idiographic studies of learning styles are rare. Yet, a guiding principle of individualized "open" education is the understanding of the unique individual as student. The idiographic study of instrinsic motivation is of significance for education. In this study, the puzzling phenomenon stiuation and the clinical-facilitative interview have been found to show promise.

RATIONALE

The aims of this project centred on developing a method for qualitatively assessing and describing curiosity/inquiry styles in individual children. The need for understanding individual inquiry styles is particularly important in the early grades, where the science curriculum tends to focus on first-hand experience and child-directed, teacher-facilitated inquiries. A further aim was to develop and describe methods for teacher facilitation of children's experimental inquiries, through enhancement of their curiosity-inquiry styles.

The data of the project (so far) are qualitative not quantitative. They are based on carefully recorded observations of children's responses to a set of tasks based on puzzling phenomena. The data also include the resporses of the task administrator who also acts as a facilitator of the child's experimental inquiry. The qualitative analysis of the data aims to arrive at general verbal descriptions of the individual's style, through descriptive analysis of protocols according to a scheme of response categories related to curiosity and inquiry.

The underlying intent was to develop strategies of assessment and facilitation of children's experimental inquiry that could be used by teachers. For this purpose the idiographic study of the learner by the teacher in a series of teacher-facilitated, semi-structured, open-ended problem situations appears to have certain advantages. Open-ended problems presumably are more common in real-life situations than problems in which specific demands are made on the child. A certain amount of structure in the task (in comparison to naturalistic observation) allows for comparisons across individuals and for qualitative analysis of protocols according to defined concepts or models. The special advantage

of the puzzling phenomenon as a focus for inquiry is that the task "demands" are incorporated in the material, as it were; ideally, the phenomenon stimulates intrinsic motivation, so that fewer demands have to be made by the adult. In responding to a puzzling phenomenon in a setting in which he feels free, the child reveals himself through his surprise, puzzlement, spontaneous manipulative curiosity and creative experimental inquiry.

The notion of facilitation is one that differs from traditional teaching styles in being non-directive. Facilitation does not aim toward a particular response but toward a class of responses, appropriate to the situation but otherwise open. The child who responds to facilitation maintains his freedom of choice; often, the best responses are creative ones. Facilitation, to be effective, is adapted to the particular child, situation, and moment. In the present work, facilitative moves were made by the interviewer only after the child's "spontaneous" responses had been allowed and encouraged; since the ultimate goal was for the child to become a self-directed inquirer, a purpose of the assessment was to discover how little input was needed to lead the child into inquiry.

The task of the teacher-facilitator-assessor is to discover, both the typical reactions and styles of the individual, and adaptive tactics by which this teacher can facilitate the individual's inquiry. The action-research question is, "How can I help this child to devise experiments?" Such a question implies that both teacher and child are factors in the situation to be action-researched. The concept of an

inquiry climate is one that encompassas the child, the teacher, the phenomenon, and the total material and social setting. When the teacher explores the question, What is the child's style and ability in experimental inquiry? this question is found nested within a larger one, What is the inquiry climate that exists between me and the child in this particular setting? The stylistic descriptions and the estimates of inquiry ability that came out of such a setting are not to be considered personality traits only; in contrast with standard methods of personality assessment, the adult invests much more of himself or herself into the relatively unstructured open-ended situation.

Several possible approaches to the facilitation of inquiry might be envisaged. One approach might be to reflect back to the child, his puzzlement, his intentions and ideas, and to interpret these to him, like a non-directive therapist. Another, more intuitive approach would be to attempt to "sense" the child's needs in a purely non-intellectual way. While these approaches were sometimes used in a limited way, the work relied mainly on a more explicit and systematic strategy. The facilitator carefully recorded and later studied and reflected on the child's responses, writing down hypothesis-questions about the child's habits, motives, styles, and abilities in and around inquiry. The facilitator thought about possible non-directive interventions which might serve to enhance this child's inquiry. The facilitator tested these hypothesis-questions and tailored interventions in subsequent sessions with the child and assessed the results. Like the field

ethnologist, the facilitator recorded interpretive notes at the end of each inquiry record. The resulting "field notes" constitute a written representation of the ongoing task of interpreting meanings for the child's behavior and devising adaptive moves to facilitate his inquiry. This approach to facilitation was suggested by Lillian Meyer's "responsive-adaptive teaching". Clearly, such interpretations rely on subjective impressions, the impressions of an observer who is very much a part of the events being observed. This approach stands in strong contrast to the method of experimental psychology, in which the observer is supposed to be "neutral" and in which interpretations are based on previously defined "objective" criteria. Whatever one's views on this issue, in the present instance there are good reasons for the facilitator to record subjective impressions.

First, the impressions thus recorded are then studied by the facilitator self-critically, in a deliberate effort to become aware of his/her own bias in the ongoing effort to "bracket out" this bias.

Second, recorded impressions can be checked against those of other observers. In the present work, there were often two persons who observed, recorded, and discussed interpretations; sometimes tailored facilitations were also subjected to discussion. (Facilitation work currently in progress is being viewed on videotape and discussed by four qualified persons.)

A third reason for recording impressions is that according to the strategy outlined, the facilitator must act on impressions. Impressionistically based hypothesis-questions lead to ideas for more effective facilitation. These ideas are then tried out with the child in another task.

Compared to much personality assessment, the present work is relatively conservative in respect to judgements made about individuals. There is very little categorizing of personalities; the emphasis rather is an individual uniqueness. In the reporting of results, there is considerable reliance on summary description of events, with sample detailed passages where space permits, so that the reader may form an independent impression of the inquiry climate and the child's tendencies. The intention is to raise hypothesis-questions in the reader's mind. Such hypothesis-questions guide the reader's impressions in continuing to read about the individual - or, in a practical setting, his impressions in encounter with the individual. In this study, any conclusions about individuals are not "conclusions" in the sense of terminations, but are directed toward re-encounter.

The foregoing considerations focus on the role of the adult as action-researcher. What of the adult's role vis-à-vis the child? Student and facilitator are viewed as creative individuals. When the student responds to the phenomenon, he creates his own structure of understanding. When the facilitator responds to the student's puzzlement and curiosity, the facilitator adaptively and creatively facilitates the student's commitment to self-directed inquiry, calling upon the student's creativity and the self-strength which that demands. Out of creative, personally committed inquiry may arise personal knowledge of the phenomenon. The facilitator asks for but does not insist on the student's verbalization of this personal understanding.

.....

In contrast to the notion of rapport, common in personality assessment and focussed essentially on the child's response to the adult, the present work focusses on the child's response to the phenomenon. Adult and child together attend to the object of inquiry. Adult, child and phenomenon are related as "I-Thou-It", as David Hawkins puts it - "A pattern of mutual interest and exchange between the teacher and the child".

> The function of the teacher, then, is to respond diagnostically and helpfully to a child's behavior, to make what he considers to be an appropriate response, a response which the child needs in order to complete the process he's engaged in at the moment. (Hawkins, 1969).

Viewed from a "science education" viewpoint, the present philosophy is probably inefficent. It awards little value to a child's success in discovering the "correct" physics of the phenomenon. Neither are the phenomena selected to fit into some grand overall instructional plan. Rather, interest lies in the process of discovery, in curiosity-based inquiry reliant upon creative ideation and analytical thinking, rooted in present and past experience of concrete reality. Personal knowledge is not achieved reliably; its verifiability depends on the vicissitudes of self-directed dicovery. It is toward strengthening the child's powers of discovery that the facilitator's efforts are directed - not toward children discovering what other people already know.

The inquiry process we sought to investigate was the process of seeking explanations and testing them. We conceived of a simple (perhaps oversimplified) model, in which puzzlement and curiosity about a phenomenon would lead to explanatory ideas, ideas that could be tested experimentally.

Briefly, the process could be represented as follows:
Perceive → wonder → manipulate curiously → ideate → test → evaluate.
We felt that if we could find sufficiently interesting phenomena, most children might experience these processes although not necessarily in the same order. Three points in this list deserve special comment.

Manipulative curiosity is so common among children that it might be considered universal. We assumed that every child we encountered could experience curiosity and the motive to manipulate.

While younger children seem to manipulate simply as a means of knowing, we thought that in children in the first two grades of school, manipulative curiosity might lead on towards the having of explanatory ideas, especially if, at the "wonder" stage, they perceived a discrepancy with the way things usually behave. Our model and our consequent procedure were built on this assumption. We shall see in what follows that our expectations for the having of wonderful ideas (or any ideas at all) were met to a very variable extent in different children.

The step from having ideas to testing them seemed obvious enough to us, with our scientifically saturated outlook; yet we soon found that when some children state an explanation they state it as a personal commitment, refusing to entertain any doubts about it. Other children, perhaps more of them, respond to the invitation to explain in the same way they typically respond to the teacher: with an "answer" which they believe will be judged either right or wrong. In neither case does the child reveal any spontaneous thrust towards finding out by testing. Some of our most ingenious efforts were devoted to getting children into a finding-out mood.

Out of this model and these assumptions we developed the curiosity-inquiry task and the puzzling phenomenon.

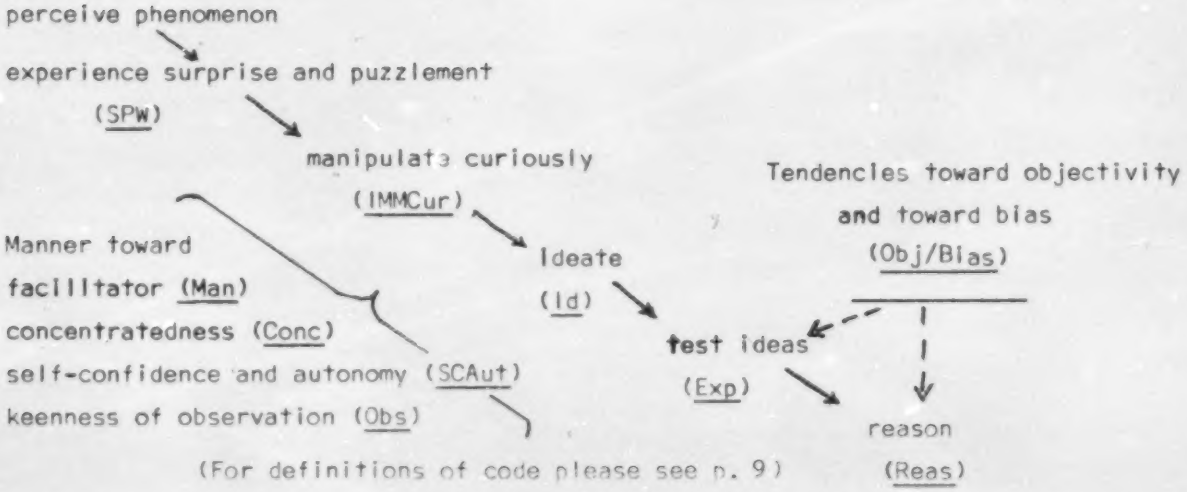
Under ideal circumstances the model on p. 7 would be validated by observing children's inquiry naturalistically. Idiographic study would then compare individual styles of inquiry with the model; as styles of inquiry continued to accumulate, a natural history of children's inquiry would develop. In practice however, we felt that such a research task would be unfeasible, and that more economical ways could be used with almost the same validity. Thus the model was made the basis of a semi-structured task. We wish to make the task as inviting as possible to children so that they would not perceive it as a "task", but would become intrinsically motivated to inquire. In so doing, we reasoned, they would reveal what we were looking for - their personal inquiry styles.

Accordingly, the task was patterned on the model as follows.

Model:

perceive → wonder → manipulate curiously → ideate → test → evaluate.

Task:



(For definitions of code please see p. 9)

The Response Categories

Preliminary studies on children were carried out using tasks that will be described directly. This work established that it was possible to assess descriptively a child's responses to the inquiry situation in terms of a number of qualities, including active curiosity, self-confidence, ideation, testing of own ideas, and so on. After some experience had been gained in studying and interpreting the protocols, ten categories of behavior were formulated that appeared to be of interest. The categories follow:

Qualities of central importance:

Surprise, puzzlement, wonder (SPW)

Intrinsically motivated manipulated curiosity (IMMCur)

Ideation about causes or conditions (Id)

Experimentalism (Exp)

Objectivity/Bias (Obj/Bias)

Reasoning (Reas)

Modifying qualities:

Manner toward facilitator (Man)

Concentratedness (Conc)

Self-confidence and autonomy (SCAut)

Keenness of observation (Obs)

.....

Notes and definitions on the ten behavior categories follow.

1. Manner toward I appeared to be an important factor in the extent to which other qualities were displayed. At certain key points, the child was allowed and indeed expected to do whatever he felt like doing. For example, no guidance was given when the child was shown the puzzling phenomenon. The assumption was that most children would experience surprise and an impulse to manipulate at this point. But surprise is an innermost feeling, and persons are more or less guarded against display of innermost feelings to other persons whom they do not know well. Another quality of interest was the impulse to manipulate; but this impulse often seemed to be inhibited by the child's concern about what I expected or would allow. In such a situation, the child's feelings about I were clearly am important factor. The child's manner to I was an indicator of these feelings. Evidence of manner toward I was sought in the verbal and non-verbal record, for example, in facial expression, body attitude and movement, and tone of voice, as well as the verbal record.

2. Concentratedness. Some children are easily distracted away from the problem at hand. Others become involved in the inquiry situation and stay "with it"; their attention does not wander to other things or other thoughts.

3. Self-confidence and autonomy. Some children show great independence, preferring to experiment with a phenomenon without adult help. Others accept a cooperative and interactive inquiry relationship with the adult. Still others seem to be totally dependent on the adult for ideas and encouragement. One gauge of autonomy is whether the child seems likely to pursue his inquiry if the adult were not with him. A child who is supplying most of the ideas and questions for inquiry may usually be called autonomous. In the presence of the unfamiliar, some children show fear or distrust, others show self-confidence. Some are willing to take the risk of making predictions, and even to state the problem of "why" (thus implying that they don't know the answer). When it comes to a matter of trying to find out "why" - the cause of the puzzling phenomenon - some children show confidence that they can find out what they want to know; others become discouraged quickly.

4. Keenness of observation. Keenness of observation is displayed when the child notices the features of things, events that are happening in the environment, and so on. Keenness of observation was revealed in the child's verbal remarks and responses.

5. Surprise, puzzlement, wonder. Included in this category was behavioral evidence of surprise, puzzlement and wonder, and also behavior indicating the suppression of such responses.

Children displayed surprise, puzzlement and wonder, or the suppression of these, in their facial expression, head and eye movements, non-verbal vocalizations, changes in breathing, body attitudes, and other body movements, as well as verbally. They also expressed SPW verbally.

6. Intrinsically motivated manipulative curiosity means manipulating an object or phenomenon just to see what will happen. This includes changing the conditions around the object or phenomenon, for example, trying it in a different place or getting somebody else to try it. Manipulating means not only handling, but also creating any kind of physical change. The key feature is the motivation: the child wants to see what will happen.

7. Ideation about causes or conditions. Some children have lots of spontaneous ideas about what is causing a phenomenon, or ideas about the conditions under which you can get it to occur. For example, in the case of the Pail That Rolls Uphill, children's ideas about causes have included magnets, electricity, the wind, and "you pushed it". Ideas about conditions included: touching the pail with your finger before you let it go, setting it at the very top edge of the ramp, and setting it at a certain angle (true). On the other hand, some children don't seem to be much interested in causes or in describing the conditions, once they have managed to get the pail to roll uphill. In the Shoe-Box Guitar task, ideas about causes or conditions are typically expressed non-verbally. In this task the idea and its testing are expressed in one and the same behavior. In the Spinning Carton task, on the other hand, the nature of the task required that ideas about causes or conditions must usually be expressed verbally.

8. Experimentalism. A child displays an experimental attitude when he is asked how he might find out if his idea about cause or condition is right, if:

(a) He demonstrates understanding that he has to find out by probing or testing and not by just thinking or talking. His probes or tests might be by looking, manipulating, or comparing, but not by discussing concepts, or by reasoning based on theory;

(b) He also demonstrates willingness to actually find out by probing or testing.

The child demonstrates experimental ability if he thinks of ways for testing his ideas that will, in fact, establish whether these ideas are valid or not.

9. Objectivity/Bias. This term refers a two-sided quality related, on the one hand, to the honesty and impartiality that are characteristic of proper experimental inquiry; on the other hand, to bias and exerting influence on outcomes. Children show varying degrees of objectivity when they are asked to test their own beliefs and predictions to find out if they are right. In such tests, children may display their objectivity in several ways.

First, the test that the child does is unbiased - the child does not "weight the scales" in favour of (his/her) stated belief, but tests as though (he/she) wanted to find out the factual truth of the matter. Second, the child reports the results truthfully and without distortion - even if it runs contrary to (his/her) prediction. Again, if the child's prediction turns out to be incorrect, the child may note that (he/she) was wrong.

Other qualities that were considered evidence of objectivity included conveying an impression of genuine tentativeness (as opposed to unalterable conviction) when making predictions, and evaluating the outcomes of one's own Id and Exp in a constructive manner.

10. Reasoning includes the degree of appropriateness of the experiments that the child proposes, to the question being raised; validity of conclusions drawn from experiments; stating propositions and reasoning out conclusions (if-then reasoning); and other reasoning.

Of the five phenomena selected for this study, one of the most reliable ones for eliciting surprise, puzzlement and wonder was the Uphill Roller. This puzzling phenomenon has been administered to over 100 children by the author, and to additional children by several cooperating teachers. We will use the Uphill Roller to illustrate the key steps that constituted the "semi-structure" that was common to all five tasks (except for variations necessitated by differences in the properties of the five phenomena).

Step 1. "Have you ever played with one of these before?" The facilitator hands the child a cylindrical container, about the size and shape of a waste paper basket, covered with color-patterned vinyl and fitted with a lid. The observer records whether the child accepts it, whether he explores it, and the extent and nature of his exploration (IMMCur).

Step 2. The facilitator takes back the container and sets it on a slope. "When I let go, what do you think will happen?"

Step 3. The facilitator releases the roller; it rolls uphill and over the end of the slope, and falls on the floor. The observer records signs of SPW.

Step 4. The facilitator waits for the child's spontaneous manipulation. The observer records the child's behavior (his intrinsically motivated manipulative curiosity, IMMCur) and the behavior of the roller.

Step 5. If there was no spontaneous manipulation by the child, the facilitator invites the child to do anything he likes.

Step 6. If the invitation in Step 5 had no result, the facilitator asks, "Would you like to see if you can make it do that?"

.....

Step 7. "What do you think makes it do that?" (Id)

Step 8. "How could you find out if you're right?" (Exp)

The facilitator's questions (appearing in quotation marks) in actual practice were adapted to the situation according to the facilitator's judgement. Particularly in Steps 7 and 8, the facilitator had to be circumspect in asking such questions, especially with children who were not accustomed to providing, and accustomed to adults accepting, tentative answers. Considerable variation in the order and occurrence of these steps was permitted, especially following Step 4. In particular, Steps 7 and 8 were used flexibly depending on the course of the interview.

Here is a psychological account of the task from the child's point of view, based on the feelings and motives that seemed to arise in the course of the many administrations of Uphill Roller and at least 10 administrations of the other four puzzling phenomena (to be described).

Some children seemed to find Step 1 inviting; others, threatening. Relatively few seemed to be bored or distracted at this stage. The purpose of Step 1 was to let the child become accustomed to handling the apparatus freely so that he would not hesitate to manipulate in Step 4.

Step 2, calling upon the child to make a prediction, was calculated to provide for surprise in the next step, by creating an expectation that would subsequently be disconfirmed. While most children thought that UR would roll uphill, in some of the other tasks many children answered "I don't know".

Step 3, intended to elicit surprise, was very variable in its effect. Many children showed no surprise but looked at the facilitator in a guarded manner; perhaps they felt that they had been tricked or put down. (In current work, we have the child create the phenomenon; this seems to result in more open, less guarded reactions).

Step 4, 5, and 6 were intended as a measure of the child's IMMCur. Manipulative response in Step 4 was counted as authentic IMMCur, and the nature of the response was considered likely to be an authentic sample of the child's style of IMMCur. Lack of responce until Step 6 was considered to reflect lack of IMMCur at this stage of the protocol. Thus if, over the course of the five tasks administered to each child (in whatever order) there was a trend toward increased response in Step 4, this was considered to represent improvement in elicitation of IMMCur.

Styles in proposing causes or conditions for the phenomenon (Id) varied over an entire spectrum. Some children proposed a cause the moment they perceived the phenomenon. At the other extreme, some avoided talking about causes through the whole task. Others proposed causes when given Step 7, but their manner made it clear that they were answering the question as though the questioner wanted a right answer.

Likewise, styles of Experimentalism (Exp) varied from immediate, spontaneous testing of ideas about cause, to avoidance of testing, lack of comprehension of the question "How could you find out", or anxious confusion. Evidently, this question meant different things to different children.

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THE PUZZLING PHENOMENA

Sixteen puzzling phenomena were tried out. All of these were composed of materials presumably familiar to children (or at least not exotic). They could be manipulated by children in various ways, and it was physically feasible for a child to identify the cause of the phenomenon or the conditions under which it would occur.

From the set of sixteen phenomena, five were selected. Some phenomena were weeded out because they seemed to intimidate some children on whom they were tried out. Other phenomena did not turn out to be inviting enough to little hands (for example the Noisy Crawling Worm phenomenon). Generally, the phenomena that were selected operated on understandable physical principles, created strong SPW, and elicited IMMCur, Id and Exp in most children on whom these phenomena were tried out.

Uphill Roller (UR)

The actual phenomenon has already been described. The uphill roller was constructed from a cardboard ice cream pail and a strip of lead foil. Construction of the uphill roller requires that the lead weight be concealed under the vinyl covering; operation requires the pail to be oriented on the slope so that the weight, under the influence of gravity, makes the pail roll uphill. The idea was found in the Teachers' Guide to Inquiry Development Program in Physical Science (Suchman, 1966).

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Returning Roller (RR)

Another idea from Suchman's Inquiry Program, the Returning Roller is a cardboard cylinder which, when you roll it across the floor, stops and then returns to you. Inside the cylinder is an elastic band stretched from end to end, with a heavy weight affixed to its centre. The two ends of the elastic band just inside the cylinder are held by popsicle sticks and concealed by removable plastic cups. The mechanism (elastic plus weight) can be removed and examined.

Spinning Cartons

A milk carton with a small hole at the bottom corner of each of its sides is suspended by a wire. When the carton is filled with water, it spins. Following Step 6 of the task, three other cartons are pointed out to the child: one with holes in the other corners, one with holes at the centre, and one without holes. After testing is completed, the facilitator and child discuss which cartons spin, and the possible reasons. (The suspension and the method of filling the cartons have, in current work, been altered to provide for more manipulation by the child.)

Bouncing Plasticine

When a ball of plasticine is dropped on thick felt, it bounces. The plasticine will bounce on some other surfaces provided, but does not bounce on certain others. The facilitator brings out these additional materials at approriate times, to see if the child will form generalizations about the kinds of surface that plasticine bounces on, and whether and how he will test his generalizations.

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Shoe-Box Guitar

A corrugated box, a very long elastic band, and a brass rod are assembled out of the child's sight; the facilitator plays a tune by striking the elastic with the rod. The arrangement is taken apart and the parts are placed in front of the child. The child is encouraged to try to re-create the phenomenon (which actually sounds more like a harpsichord than a guitar) and also to make varied sounds.

Psychological and Scientific Properties of the Five Puzzling Phenomena

Differences were noted in the kinds of hypotheses and related experiments inspired by the five phenomena.

UR tends to create two kinds of interest: (1) interest in getting the phenomenon to work, getting the pail under manipulative control, and describing how it is done (the conditions of the phenomenon); and (2) interest in discovering causal factors, ascribing influence to different features of the roller such as its cover, its weight distribution, etc. The possible influence of the cover can be checked by what Piaget has called negation, viz., by removing the lid and testing again. In RR, many children ascribe causal influence to the parts (caps, or elastic and weight). They may test these claims by negation experiments (removal of the part in question). The child may observe the operation of the mechanism inside the roller (with the caps off) as he rolls it across the floor.

In SC, the several features that influence the phenomenon provide for progressive development of an explanatory hypothesis, e.g. (1) water in carton; (2) water spray; (3) corner holes but not centre holes; (4) geometry of holes in relation to direction of spin; (6) mechanical-causal hypothesis - the notion of action/reaction.

In BP, the inquiry process usually amounts to the forming and testing of generalizations. These refer to physical properties of the objects being tested by dropping the plasticine on them - properties such as softness, flexibility, and so on. A unique feature of BP is that it tends to lead outwards from the particular apparatus at hand into an infinite set of ther materials that might profitably be tested in order to refine a hypothesis. Concomitantly, the physical concepts of compressibility and elastic recovery may develop. (Many children volunteer a primitive notion of elastic recovery.)

In comparison to the other tasks, SBG depends on aural rather than visual and tactual perception. In SBG, two motives tend to arise: to try to discover how to play a tune, and to make varied sounds. Both motives are encouraged, and all such ideas are counted as Id. Since, in SBG, most children demonstrate their ideas directly by manipulation rather than verbally, (a) these manipulations are counted as ideas about conditions of the phenomenon (Id); and (b) there is seldom much Experimentalism(Exp)in the sense of testing verbalized ideas. Likewise there is usually relatively little evidence of reasoning (Reas); the child tends to concentrate on manipulation and usually says relatively little.

This task drew out, from various children, responses that were very creative in a divergent sense and responses that were surprisingly well-focussed, including a few successes in the difficult task of discovering how to create the phenomenon.

For shy children, SBG tended to elicit more Id response than those tasks in which ideas had to be conveyed verbally. The SBG task seems to have promise as a means for evaluating creativity in the sense of creative problem solving.

Certain common features and differences between the five tasks may be recognized. In UR and SBG, discovery of conditions depends on arranging and manipulating the apparatus in a certain way, whereas in BP and SC it depends on perceiving differences and similarities in the properties or structure of the different pieces of apparatus that are being tested. UR and RR both contain an object (lead strip, elastic plus weight) that has to be looked for and found; efforts to find these causal features usually include several similar manipulations (rolling in different ways, looking for external influences such as magnets, shaking, opening up to look inside). However, unlike RR, the lead strip in UR, if it is discovered, is usually discovered by simple visual or tactual inspection.

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FACILITATION TECHNIQUES

We are looking forward to the time when it will be possible to present a general discussion of inquiry facilitation and a typology of methods. We have already mentioned the hypothesis-testing approach to tailoring facilitation to individuals (above p. 7). For the time being, here is a casual list of techniques that were used to facilitate the child's inquiry from one moment to another within an inquiry task.

1. Attend to the child's priorities and concerns. These may range widely. If the child is afraid of the apparatus, give reassurance. If the child is uncomfortable, do whatever can be done about it. If nothing can be done (for example a loose tooth), then try to get the child to discuss the problem. Carry on the discussion until the concern seems to have been resolved, before proceeding.

> In session 5 (S&G), Nan was at first uncomfortable (she had a loose tooth), and distrustful. Nan and I discussed her loose tooth. Nan became more trustful, for example describing her plans for the weekend. I suggested that she might rather go back to the classroom. In response, she expressed renewed interest in the rod and elastic, and put on a little violin act with this apparatus, speaking in a childish sing-song.

2. Make sure the child knows that he or she is free to leave the situation and to return to the classroom at any time. The underlying assumption is that good inquiry requires personal commitment and an atmosphere in which the child feels free.

> Frequently, when I hinted that the inquiry was coming to a close, Sha responded by showing revitalized interest.

3. Adopt a supportive role rather than a directive or examining one. Make general suggestions in preference to explicit ones; imply ranges of ideas or things to do in preference to suggesting particular

moves. Avoid asking the same questions too often. The aim is to create a climate of events and ideas that suggests and stimulates thinking, rather than a climate of expectations and demands.

4. Put into words what the child is doing. If you do this in an interested, appreciative way, it is likely to have a reinforcing effect, as well as helping the child think about meanings of events and spin off new lines of thought.

> I asked if she could make violin sounds, and although she thought not, she started to make sounds with the elastic and rod. As I described these sounds to her, and continually expressed interest and approval, Nan became absorbed and fully involved.

> When Sha concluded that the plasticine didn't bounce on Styrofoam, I remarked that Sha was dropping the plasticine ball on the Styrofoam from a few inches height. Sha responded by trying three other heights on Styrofoam, and similarly explored the height variable on several other materials.

5. Summarize periodically what the child has done and found out; help the child to review. This is often effective in leading the child to recognize missing elements in his inquiry, and fill these in.

> In UR, when I noted approvingly that Sha had succeeded in getting the roller to roll uphill, Sha responded: "But I don't know how it does it."

> After I summed up what she had found out, Sha indirectly retracted her claim that the weight rolled by saying, very clearly and with gestures, "How come it only rolls like that?" (back and forth)

6. When appropriate, remind the child that he/she can do anything he/she wants - for example, when the child is hesitating.

> Jan got K to look inside RR. They discussed what it was that they saw inside. I said they could do anything they liked with the roller. Jan: "Except take it apart." I assured Jan that they could take it apart, and helped to make it possible. Jan immediately proceeded to disassemble the roller.

7. Priactice the art of encouragement. Adapt to the child's needs by appreciating and approving what he has done, conveying your impressions of what he is able to do - depending on what is appropriate to the moment. But avoid trying to convert boredom or distraction into interest. A child who is bored or distracted should be give permission to leave. Encouragement should be used when (a) the child is trying but failing, and (b) there seems a likelihood of him succeeding.

> Bill seemed to feel inadequate to the challenge of trying to play a tune with the elastic, box and rod. I stretched the elastic across my hands and invited him to play it; as he did so I constantly and appreciatively verbalized what he was doing and what he was going to do. I directed his attention to the box, and I finally suggested that he see if he could make sounds with it. He stretched the elastic around the box and plucked it. The results must have excited him because he continued steadily, as I constantly verbalized and praised what he was doing. He seemed committed to a goal of duplicating the puzzling sound, repeatedly developing and strengthening his ideas.

8. When the child proposes an experiment that you know will not answer the question, you may be able to get him to think more carefully about it by asking certain kinds of questions. For example, you may ask him again what the purpose is; you may ask for details on how he is going to carry it out. You may wish to avoid questions that imply criticism, such as, "How is that going to show you whether...?" Rather, your questions should implicitly convey that it is his job to invent an appropriate experiment.

9. When arranging for group inquiry, team up the children to have a beneficial effect on each other. Sometimes, children choose partners with whom they work well.

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Mic, when playing with the radio and WM, became unprecedentedly easy, talkative, responsive, and humorous, to I as well as to Bil and SMB. Mic obviously worked better when in the company of his friends than when alone.

In other cases, children seem to choose partners for the "wrong" reasons.

Jan chose SFA and K (Grade 1) to work with. This group turned out to be concerned about each other much of the time, with much conversation and some competition between Jan and SFA for possession and control of the apparatus. Jan's attention seemed to be divided between getting the equipment to work, and establishing her position in the group.

10. Once the child seems interested and committed, it may be appropriate to offer a challenge.

Ros energetically worked on the Cartesian Diver, with a partner. I challenged her to see if she could get the diver to sink part way down. She tried a series of four non-verbal ideas, expressed a verbal explanation, then tried two more manipulative ideas. The last of these ideas was successful in getting the diver to float at rest, slightly off the bottom of the jar.

11. Plan the sequence of tasks carefully for the individual. Be patient - keep trying.

The foregoing example of Ros was taken from the last of a total of ten tasks administered to her, over a period of months. In the first task (BP) she had given virtually no response at all. She was next given two "warm-up" tasks - short, simple phenomena using apparatus not too unfamiliar - still with minimal response. The remaining tasks followed in a sequence calculated to let her drop her inhibition a little at a time. The foregoing excerpt demonstrates the possibility of success using a "tailored" approach.

SUMMARY STATEMENTS
ON THE
INQUIRY STYLES OF INDIVIDUALS

Pet

To a remarkable extent, Pet's finding-out fitted the model: perceive, wonder, hypothesize, test, evaluate, and wonder again. In general, Pet showed at least as much MCur as any child tested. In all tasks, his MCur continued for a long time. Generally, his MCur was free and varied (although in SBG(5), it was sometimes hesitant and even stilted - he was in a "bad mood" on this day, according to his teacher.) A consistent feature in all tasks was Pet's habit of verbalizing as he manipulated; thus he revealed the thought processes accompanying his MCur. In general, Pet's ideas were notably creative, his inquiry deeply involved, open, and objective. He showed no anxiety about being judged externally, and his conclusions were careful and open-ended. But on occasion he could become overly intent on certain manipulative ideas or empirical strategies. Although in most tasks he wanted to continue longer than the time allowed, on one occasion (UR) he ended by saying, "I give up."

Mor

As Mor progressed through the five tasks he became progressively less anxious about achieving a solution, less focussed on the facilitator and more on the phenomenon, and more autonomous. Still, in the fifth task, Mor tended to wait for guidance as much as he tended to volunteer ideas. Except for BP (in which he seemed to lack intrinsic motivation) Mor displayed

a characteristic quality of puzzlement - thoughtful, bemused, humorous, and self-aware - and a characteristic caution and concern for correctness in expressing ideas about causes or conditions. In getting at mechanical causes, both his interest and ability seemed to be weak. He showed a tendency to voluntarily test his ideas by experiment in a thoughtful, patient, well-focussed style; but he often seemed reluctant to carry out tests when he was asked to do so. His caution and concern to avoid error carried over into his style of objectivity, which went beyond caution and tentativeness; his tendency to evaluate his own ideas sometimes verged on self-criticism.

Joa

Although Joa seemed very self-assured, responsive, willing, verbally inquisitive, and even bossy at times, her evident desire to keep on top of things may have masked a fearfulness of strange objects and of losing her self-esteem, for example by being proven wrong. Usually, her realism and curiosity won out over her defensiveness. Joa showed little or no surprise, facially or vocally. Her expressions of puzzlement and wonder were infrequent and tended either toward pleading for the answer or toward superficiality. Joa's manipulative curiosity varied greatly in different tasks, perhaps reflecting her tendency either to be cautious or to throw herself into varied activity. In manipulation, as at most other times, Joa had a lot to say about what was happening and what she intended to do. She tended to involve the facilitator in the manipulative activity, sometimes competitively, sometimes dominatingly.

In all tasks her manipulation was prolonged and diversified, but not always focussed or even coherent.

Joa's ideas about causes and conditions came readily but not always clearly. She was consistently willing to test her ideas, but her objectivity wavered in the first three tasks. Also in the early tasks her logical reasoning was sometimes at fault. Of the many weaknesses and faults listed above, most were not evident in the final task (RR). In this task one could see Joa at her best. She openly expressed puzzlement and wonder, showed a less compulsive kind of curiosity, and had ideas focussed on inquiry, not calculated for their effect on the facilitator. Her honesty and objectivity were on a much higher level, and in her reasoning, the logic was faultless and the level more mature. These improvements seemed to be connected with her evident mood of relaxation and improved self-confidence.

Nan

Nan tended to approach the sessions in a negative and cautious mood. She consistently showed surprise at all five phenomena. Her reaction to the invitation in Step 6, "You can do anything you want", tended to be one of suspicion. The facilitator's task in each case was to reassure her concerning her fears, give her carte blanche to leave whenever she wished, and verbalize and praise her efforts. Once Nan became involved in inquiry she showed relaxed effort, courage and creativity. She frequently expressed ideas about causes and conditions (most readily when the facilitator created opportunities for her to make choices); some of these were unusually powerful in concept or technique.

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When relaxed and confidnet, Nan tested her ideas with experiments that seemed to be intrinsically motivated, but in her passive, fearful, distrustful or uninterested moods, Nan did not experiment. Nan displayed varied styles when predicting results, according to her mood (as evidenced especially by her tone of voice). These styles ranged from passive and reluctant, through hesitant and tentative, to assertive and even arbitrary. Once she had engaged herself in inquiry, Nan sought explanatory evidence by formulating a hypothesis and testing it against other results either by doing experiments or recalling previous results. Beyond Nan's superficial limitations (below-normal physical strength, anxiety, fear and tendency toward suspicion) lay a flexible, thoughtful and inquiring personality, capable of intense commitment and powerful, rational methods of inquiry.

Sha

Upon witnessing a phenomenon, Sha tended immediately to state attempts at explanation. Having verbalized an idea, she often seemed to evaluate it internally, occasionally rejecting an idea as though finding it implausible or inconsistent. Although tending to react quickly and carelessly, she seemed to evaluate and try to refine her observations, explanations and plans, as though aiming for precision and accuracy. She readily tested her explanatory ideas experimentally; several times she showed that she could vary a factor in order to see if it had an influence. In the light of the experimental evidence, Sha accepted or rejected or modified her explanations. Consistently, Sha's experimentalism seemed intensely involved and focussed on a specific goal. Yet Sha liked to play, to test extraneous possibilities, and to fool the facilitator.

Bil

Bil's mood varied among the five different tasks (which were administered over a four-month period). At various times, his moods suggested lack of interest; intense concentration; hyperactivity and distraction; and diffidence. Yet Bil was almost always attentive and responsive to the facilitator.

Except for SC in which he was only slightly interested, Bil showed a very strong tendency to manipulate the experimental materials. His manipulation tended toward periods of intense, constant activity, sometimes but not always repetitive, compulsive and even frenetic. However he could also manipulate thoughtfully and in a goal-directed manner.

The extent of Bil's ideation about causes or conditions varied considerably in different tasks. He consistently tended to avoid testing his ideas to see if they were correct. But when his ideas were disconfirmed he recognized this without bias. Bil's best moments came in SBG, when he was able to produce and develop his ideas manipulatively. Here, his ideas came rapidly and had an intelligible direction to them.

Mic

Mic tended to stiffen physically in an unfamiliar situation, and to respond minimally, frequently answering "I don't know". He seemed precise and confident in his voice and speech - but there were occasional puzzling weaknesses in the content of his responses. He tended to gulp and to rise up on his toes when asked a question.

Mic showed no surprise or puzzlement in any of the five tasks. He tended to do things that resulted in little being accomplished. For example, in the early tasks, his manipulations tended to be repetitive, leading nowhere and seeming to be aimless. And from time to time he would stop what he was doing and look around the room, wide-eyed, or else off into space. However, in the later tasks (BP, RR and SBG) his manipulation was more varied and goal-focussed, and in some cases it appeared to be motivated towards inquiry. Thus, in scattered instances at one time or another he (1) carefully tested until he knew exactly how to get the phenomenon, then proceeded to explore its limits; (2) showed "divergent production" in his manipulation, and had some ideas about conditions; (3) showed focus on a goal, and carried out divergent ideas alternating with repetitive, mechanical manipulations. In experimentalism Mic was consistently weak.

His verbal interaction with the facilitator showed repeated signs of confusion.

Tom

Tom generally showed tension both in the classroom and in the inquiry climate. Although attentive and responsive, he seldom if ever looked directly at the facilitator; habitually, he kept his head down. His voice tended to be very quiet, sometimes sulky, often a whisper or a mumble. His speech was tense and sometimes halting, as though anxious about what he would say; habitually, his remarks tended to end in a questioning inflection, as though asking if he was right.

He tended to answer very promptly - perhaps hastily; his answers were very short and sometimes inappropriate to the question or inconsistent with what he had said previously.

Tom showed much more self-confidence in respect to the phenomena. His Manipulative curiosity was his typical reation to a new situation; it was immediate, eager, intense, and both focussed and extended, in a pattern that tended to diverge from and return to a central concern. He never asked for help; when help was offerred on one occasion, he expressed fierce independence. Although his concentration in self-directed manipulation was intense, he was uncomfortable in making explanations - both when asked and on his own volition. Sometimes he responded to such questions by proposing many causes for a phenomenon, even contradicting himself. Tom sometimes handles demands for discussion abruptly, sometimes confusingly. He especially disliked being asked how he might test his explanations. On one occasion, when the facilitator attempted to get him to reflect on his own (ciricular) reasoning, Tom became sullen and lost interest.

Tom's keenness of observation and inclination to examine things exhaustively led him to discover the operative parts of UR, RR, and SC. He produced a physical explanation for BP (plus some illogical ones) and in SBG he created many sounds including the phenomenon itself which, however, he didn't recognize.

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Jan

Jan was open and direct with the facilitator, and responded confidently and honestly. She offerred constructive cooperation, and conversed spontaneously and interactively. Her face was mobile, especially in expressing surprise and puzzlement - which she consistently did. Jan tended to express puzzlement repeatedly throughout a task, in a unique style. While her words and tone of voice expressed utter incomprehension, even hopelessness about discovering "what makes it do that", her manner remained confident, alert, and eager. Sometimes she sighed and spoke in an exhausted tone - in the midst of energetic activity! Her sighs and bright, delighted expression were as though she was overwhelmed by the huge excitement of her own wondering and experimenting.

Jan had a nice sense of appropriate, and seemed to be concerned to fit into the situation smoothly; for example, although she readily explored the apparatus when it was handed to her, she never picked it up after the phenomenon until permission was expressly given. Jan showed a strong inclination to find out how things worked. She stated explanations conscientiously and tentatively, and tested them with appropriate experiments in an open, objective manner. She often preferred to say "I don't know" rather than make guesses. Only in RR did she fail to verbalize ideas or do experiments; she was inhibited because a stranger was watching. Later, when RR was repeated, she resumed her usual active inquiry style.

Ros

Although Ros's manner toward the facilitator varied greatly from one task to another in respect to her responsiveness and interactiveness, there was one aspect that was consistent. Ros seemed to be anxious about being watched at work or play, and about observers taking notes of her behaviour. (This was also noted in the classroom.)

Ros smiled a lot but spoke rather seldom to the facilitator. She often showed subtle signs of anxiety and inhibition. Because of her general lack of response, Ros was given two preliminary warm-up tasks (based on simpler puzzling phenomena) to try to reassure her and let her become accustomed to the inquiry situation.

Ros's style of manipulation varied. Sometimes she displayed a rapid stream of varied, eager, almost impetuous manipulative ideas (as in SBG and RR). At other times she manipulated repetitively with little variation (as in UR). The latter style may have been related to her occasional habit of mental withdrawal, playing with the apparatus as though there was no-one else present. Her ideas about causes and conditions were sometimes physically plausible, sometimes magical-animistic.

Ros offerred no verbal ideas and did no experiments in three of the five main tasks: UR, RR and BP; these might be called the three least-structured tasks involving highest risk to the child's self-esteem. Ros offerred some sketchy verbal ideas about the cause of SC - this was her best verbal performance. After all tasks had been administered, Ros was allowed to watch other children playing with RR

and then was given RR again, and also BP. Although she was still too inhibited to make much of BP, in RR she was more focussed in investigating the cause. She did a spontaneous negation experiment to establish the influence of the weight and elastic.

Except for this work and some of her work on SBG, Ros was too much concerned with the adults present to permit herself to become involved in inquiry. We had to wait for the classroom validation tests in order to see evidence of what could legitimately be called an inquiry style.

We wanted to study the tasks as means for assessing and developing the inquiry climate between facilitator and child. We intended to focus on the six response categories of central interest (SPW, IMMCur, Id, Exp, Obj/Bias, Reas) that were defined on pp. 15-19 above. We would seek to elicit these qualities in the process of facilitating the child's inquiry, and would analyze the records of the session according to the same categories.

The Children

We chose 10 children for the study. Two samples of five children were randomly selected, one from an "advanced" private metropolitan school (School M) and one from a small rural school (School S). All ten children were in Grade 1 or Grade 2. All ten children were given all five main tasks, and several in the rural school were also given warm-up tasks.

Recording of Data

Records of each protocol were taken as follows. All verbal and other sonic events were tape-recorded and later transcribed stenographically, including descriptions of tone of voice. Non-verbal behavior was hand-recorded by the interviewer and an accompanying observer. The sonic transcript and the non-verbal record were combined into a single synchronous protocol for qualitative analysis.

Interpretive Analysis of Data

Protocols generally were coded on the ten idiographic qualities (six centrally important categories and four general modifying qualities). Since protocols differed greatly due to the adaptive course of the task, a summary of each protocol was first prepared. Then a summary description of the responses that had been coded under each of the six centrally important idiographic headings was derived from the protocol. Thus each of the fifty protocols (five tasks for each of ten children) generated six idiographic notes, one for each of Int, InMCur, Id, Exp, Obj, and Reas. These notes constituted the main descriptive data of the study.

Some children on some tasks revealed a good deal of their inquiry style, on one or another of the six response categories. In other child/task instances, there was less response data in certain categories.

From a study of the descriptive data, the tasks were subjectively rated as to the extent to which each task elicited responses permitting a qualitative description of each curiosity/inquiry quality from each child. The results are shown in Table 1.

Table 1 presents ten individual ratings in each cell, for the five children at School M and the five children at School S; the means for School M and School S; and the overall mean, representing the mean extent of the response data for that category and task.

The School M means are higher, in most cases, than the School S means, reflecting the greater inquiry sophistication of the School M children (which was obvious to the observers). The School S ratings are particularly low in the Objectivity/Bias category, probably reflecting the less intense commitment of the School S children to experimental hypotheses, and also in the Reasoning category in which they gave relatively little response.

The overall mean represents a rating of the power of the task to elicit qualitative data in that response category. The highest overall mean was 3.0 (the maximum possible rating) for ideation about causes or conditions (Id) in the Shoe-Cox Guitar (Sbg). It signifies that SBG elicited a high amount of qualitative data on Id from all 19 children. Evidently, SBG is a comaratively powerful means for discovering childrens' styles of creative - manipulative ideation.

On the other hand, SBG elicited a relatively low amount of intrinsically motivated manipulative curiosity (IM*Cur), on the average, in the step in which the child was permitted to explore the apparatus before the phenomenon was demonstrated. It is important to note that this figure (1.4) is <u>not</u> comparable with the other figures in the IM*Cur column which included manipulation both <u>before and after</u> the demonstration.

As expected, task SBG produced low ratings in the Experimentalism and Reasoning categories. SBG does not tend to elicit verbalized experiments nor does it afford much opportunity for reasoning.

TABLE I

Subjective Ratings of Tasks: Extent to which Tasks Elicited Centrally Important Curiosity/Inquiry Qualities[1,2]

Tasks	Curiosity/Inquiry Qualities											
	SPW		IMMCur		Id		Exp		Obj/Bias		Reas	
	Individual	Mean	Individual	Mean	Individual	Mean	Individual	Mean	Individual	Mean	Individual	Mean
Uphill Roller (UR)												
At School M	3,3,1,2,2	2.2	3,2,2,2,0	1.8	3,1,3,1,2	2.0	3,3,3,1,3	2.6	3,2,3,1,3	1.4	2,2,3,1,2	2.0
At School S	3,0,0,3,1	1.4	3,0,1,2,2	1.6	3,1,3,3,2	2.4	1,1,2,3,0	1.4	0,0,0,2,1	.6	2,0,0,2,0	.8
Overall Mean		1.8		1.7		2.2		2.0		1.0		1.4
Returning Roller (RR)												
At School M	3,2,1,2,2	2.0	3,3,3,3,3	3.0	3,2,3,3,3	2.8	3,3,3,3,3	3.0	3,2,3,3,3	2.8	1,2,3,3,2	2.2
At School S	0,1,0,1,0	.4	3,3,3,1,2	2.4	1,1,3,0,1	1.2	0,2,3,0,0	1.0	0,1,2,0,0	.6	0,2,3,0,0	.1
Overall Mean		1.2		2.7		2.0		2.0		1.7		1.1
Spinning Cartons (SC)												
At School M	2,1,0,2,2	1.4	3,2,3,2,0	2.0	3,2,2,3,3	2.6	3,1,2,3,3	2.4	3,3,3,3,3	3.0	2,1,0,3,3	1.8
At School S	0,1,2,3,0	1.2	0,0,3,2,0	1.0	3,1,3,3,1	2.2	1,0,2,2,1	1.2	1,0,0,1,0	.4	1,1,1,1,1	1.0
Overall Mean		1.3		1.5		2.4		1.8		1.7		1.4
Bouncing Plasticine(BP)												
At School M	3,0,0,2,2	1.4	3,1,3,2,3	2.4	3,2,3,2,3	2.6	3,2,3,3,3	2.8	3,1,2,3,3	2.4	2,1,2,2,3	2.0
At School S	1,1,0,0,1	.6	3,2,3,3,0	2.2	1,2,3,3,0	1.8	1,2,3,2,0	1.6	1,1,1,2,0	1.0	0,1,1,2,0	.8
Overall Mean		1.0		2.3		2.2		2.2		1.7		1.4
Shoe-Box Guitar(SBG)			(Note 3)		(Note 4)							
At School M	3,1,1,3,2	2.0	1,1,3,0,2	1.4	3,3,3,3,3	3.0	0,1,0,2,3	1.2	3,3,2,1,3	2.4	0,1,0,1,0	.4
At School S	1,0,1,3,0	1.0	0,3,1,1,2	1.4	3,3,3,3,3	3.0	0,0,1,0,0	.2	1,0,0,0,0	.2	1,0,0,0,1	.4
Overall Mean		1.5		1.4		3.0		.7		1.1		.4

1. Task method includes all of I's facilitative moves adapted to individuals.
2. Ratings are of the extent to which the task provided for qualitative description of style, not necessarily quantity or intensity of response. 1=low, 3=high.
3. Exploration step only.
4. Including all ideas for making sounds after phenomenon was displayed.

TESTING OF HYPOTHESIS-QUESTIONS ABOUT INDIVIDUALS

BY OBSERVATION OF SMALL-GROUP INQUIRY IN CLASSROOM

After the five curiosity/inquiry tasks had been administered to the ten children individually, and hypothesis-questions about their tendencies in respect to the six response categories had been formulated, the validity of these hypothesis-questions to classroom situations was tested as follows.

Each child was asked to choose one or two partners to work with him/her in a short inquiry project. Two or three new inquiry tasks were given to each group. The conduct of these tasks, (which were carried out in the classroom) was generally less adult-structured and more child-directed than the five individual tasks (which had been administered in a separate room).

Small-Group Tasks

Code

WM Wireless Microphone: A cassette recorder is made available to the inquiry group, and then an FM radio. The children are shown how to connect these to record radio broadcasts. The radio and cassette recorder are moved to another room. Then a wireless microphone is shown to the children, and discussed, with the microphone switch on. The radio and cassette recorder are recovered from the other room where they have been recording the conversation picked up by the wireless microphone (WM). The conversation is played back to the children.

As in previous tasks, the focus child is observed for surprise,

puzzlement and wonder (SPW), manipulative curiosity (M*Cur), ideas about causes and conditions (Id), etc. Also as before, these responses are encouraged and attempts are made to elicit experimentalism (Exp), logical reasoning (Reas), etc., as required.

Code

Bs&Bs Batteries and Bulbs: Each member of the small group is provided with a flashlight battery, an insulated wire with bared ends, and a flashlight bulb. No instructions are given. Supplementary materials include additional flashlight batteries and transistor radio batteries.

If the child's interest seems to be running down, the adult lights the bulb with the battery and wire concealed below the edge of the table and only the bulb showing. Records included each arrangement of battery, bulb and wire created by the child, child-to-child interactions, etc.

The structural similarity of Bs&Bs to the Shoe-Box Guitar task (SBG) will perhaps be evident. As in SBG, ideas in Bs&Bs were typically expressed non-verbally and their expression constituted an expression of Experimentalism (Exp) also. The Bs&Bs apparatus also tended to elicit the other personality qualities of interest (cf. P. 10, above).

CD Cartesian diver. A Mason jar filled with water has an empty medicine dropper floating in it. When the cap of the Mason jar is pressed, the medicine dropper sinks to the bottom. At first, no instructions are given. Later, the children may be asked to try to get certain effects with the diver, such as floating part way off the bottom.

Results

School: M

Child: Pet

Hypothesis-questions

1. Would Pet show intense, prolonged, free and varied manipulative curiosity, revealing his thought processes at the same time?

In WM, Pet spontaneously pressed cassette recorder controls. Free, curious and spontaneous in manipulating and talking about the apparatus. In Bs&Bs, after his anxiety about being "electrocuted" was dispelled, Pet proceeded to manipulate the battery, wire and bulb. Watched as MFF lit her bulb, then got his lit. Pet's style was careful and concentrated on one or a few ideas. I gave Pet a second battery and wire - he responded enthusiastically and asked for a second bulb as well. He immediately began to manipulate.

2. Would Pet become over-committed to certain manipulative ideas or empirical strategies?

In Bs&Bs, he tried one arrangement only, in the basic task. He discovered, and later correctly described, how to light the bulb. In a subsequent task with two batteries, two bulbs, and two wires, he had only one basic idea. He developed this idea in one direction, abandoned it when it did not work, and developed the idea in another direction. The latter development involved taping the connections with masking tape. Of course this did not work either. "It doesn't work", Pet said despondently, and gave up. "I thought this will work."

....

School: M

Child: Mor

Mor was reluctant to get involved in the two classroom tasks. This resembled his reluctance to leave the classroom in three of the five earlier tasks. Just as in SC, he again seemed to defend himself against the demands that he perceived that the facilitator was making.

In Bs & Bs, Mor's inquiry style seemed very much the same as earlier: thoughtful, patient, and well-focussed. Unlike the first few tasks earlier, Mor showed no anxiety about solving the Bs and Bs problem. His style resembled that shown in his better experimental performances (SBG, RR, SC) and was unlike BP when he became overcommitted to a goal.

School: M

Child: Joa

As in the earlier tasks, Joa tended to be self-willed and to dominate - this time she dominated her chosen partner, (who was self-critical and submissive to Joa). Joa cleverly frustrated some of the intentions of the facilitator, as she had done earlier.

In Bs & Bs, Joa was intent on getting the bulb to light, but simultaneously, as a sideline, she kept up a subtle putting-down of her partner. This pattern is not unlike the pattern of two alternating and sometimes conflicting motives in earlier tasks, in which Joa was concerned to find out but also to control I.

Joa repeated over and over again one particular schema in Bs & Ps; her repetitiveness in that situation, which she seemed to perceive as a competition, recalled her wish to play her competitive game with the spinning carton "lots more times".

School: M

Child: Nan

In WM, at the beginning, Nan showed unconcern, lack of motivation, and fear, much as she had at the beginning of most of the earlier tasks. She expressed her unconcern with the problem to her workmate MFO much as she had to the facilitator.

Her gradual move from lack of interest to experimental curiosity is exactly similar to the earlier pattern. Her first expression of interest was in a style familiar from four of the five earlier tasks: the style of a dispassionate observer, reserving to herself the right to participate or not, as she would choose, but becoming aware of a dawning interest in the situation.

In Bs & Ps, Nan displayed other qualities seen earlier: reliance on observation, difficulty accepting open-ended instructions, expressive rather than problem-solving manipulation in the early stages, exasperated puzzlement, reflective thought, and intense commitment to solving the problem.

School: M

Child: Sha

Hypothesis-Questions:

1. Would Sha's motivation and skill in formulating explanations, and her drive to achieve complete solutions, show up again?

In WM, Sha's interest in explanations showed up in asking questions about how to operate the tape recorder, and her skill in explanation showed up when she explained how the cassette recorder was able to tape their voices while they were in another room: "Because this cord is attached to here (radio output) and here (cassette output)."

In Bs & Bs, her evaluative dissatisfaction with incomplete solutions, shown earlier for example in UR, showed up again when she got a larger bulb to light but expressed dissatisfaction with its lack of brightness.

Sha explained to O, when asked, how to connect the parts. She was at pains to make her meaning clear. Thus she again demonstrated accuracy in explanation, or at least her concern that her precise meaning should be understood correctly.

School: S

Child: Bil

Hypothesis-Questions:

1. Would Bil's intensely active IMMCur show up again?

Bil chose Mic and SMB to work with. As in the earlier tasks, Bil very actively manipulated the materials (in this case, the tape recorder, radio, WM). At the beginning of the WM task, he even removed Mic's and SMB's hands in his eagerness to get his own hands on the apparatus. His "covering up again" schema, displayed in UR and RR, had its parallel when he proposed extending the radio antenna but actually stowed it. He often showed haste, for example by pushing the tape recorder buttons and listening to the microphone in rapid alternation - too rapid to get any meaningful result. His IMMCur seemed scattered, and laced with anxiety - as it was in RR. But Bil slowed down and became thoughtful when the puzzling phenomenon dawned on him.

2. Would Bil have few ideas as to cause, and would he avoid testing his ideas, as he consistently did in the earlier tasks?

In WM, Bil had several ideas for experimenting to find out whether the voices were being picked up by the tape recorder or by WM. In wondering, proposing ideas, proposing, carrying out experiments, and drawing appropriate conclusions from a number of experiments with the tape recorder, radio and WM, Bil showed SPW, Id, and energetic and committed Exp and Reas. Although he tended to lose focus on the questions being investigated throughout the somewhat scattered tests that eventuated, he was willing and able to review these tests. Bil played the role of scientific investigator and team leader with unexpected but evident enthusiasm. Notably, he showed interest in planning, good recall, and logical reasoning. In these respects Bil's Exp was different from the earlier tasks, in which he seemed to avoid testing his verbal ideas. Perhaps, earlier, he felt less threatened by the possibility that "finding out" might prove him wrong; he surpassed both of his workmates in energy, initiative and ideas, and this may have boosted his confidence.

Bil and his workmates did Bs & Bs the same afternoon. Far from being scattered now, Bil worked over one idea at a time, trying slight variations when his first arrangement didn't work. He tried about six main ideas in this way. Bil's systematic try-outs were similar in spirit to his attempts at systematic tests in WM that morning. His pattern of ideas was somewhat similar to his ideas in SBG, in that both patterns suggested goal-directedness rather than simply variation for its own sake.

School: S

Child: Mic

Hypothesis-Questions:

1. Would Mic, in response to I's (facilitator's) demands in the task, tend to become tightly self-controlled and self-limited in speech, movement and manipulation?

As noted in an earlier section, Mic was much more relaxed, active, communicative and expressive when working with WM with two of his friends than he had been in the individual tests. Still, when I tried WM around his neck, Mic showed tension in the same ways as before, and also when I asked him a question.

In Bs & Bs, Mic was responsive and even forward with I. Perhaps because of the satisfying experience with WM that morning, he addressed I more often and with more confidence than usual. Generally, Mic's manner toward I was much more open and relaxed than previously.

By the time Mic got to the Cartesian Diver task (CD), he was humorous and conversationally interactive with I.

2. Would Mic, instead of taking opportunities to vary his manipulations, tend to manipulate repetitively?

Mic showed no tendency to repetitive manipulation in WM. (It seemed that when Mic showed repetitiveness rather than divergent production, it was his way of escaping from a pressing situation. Not only did it give him something to do, but it tended to stop I from creating more demands.)

In CD, Mic's early exploration was repetitive but normal for a child's first encounter with such a phenomenon; Mic soon became focussed on goals and his manipulation was appropriate to, and a part of, his thrust toward solutions. Mic's ideas in Bs&Bs were somewhat repetitious in that he varied the details of each hook-up, as though mechanically permuting the set of connections.

3. Would Mic show little wonderment or puzzlement, and little interest in causes, as he did in most of the individual tasks?

In WM, Mic expressed wonder, but his interest in causes was limited to his partner's (Bil's) experiments. In Bs & Bs, his interest in the task may not have been in lighting the bulb; his manipulative "ideas" may have actually been rather a matter of "building" with the apparatus in imitation of his respected partner Bil. In CD, Mic answered "why" questions, proposed ideas about causes and conditions, and experimented on these ideas. As a result he was successful in getting CD to work again.

School: S

Child: Tom

Hypothesis-Questions:

1. Would Tom have little to say; would he speak in a whisper or a mumble, sometimes jerkily, conveying shyness, tension, a sulkiness?

In WM, Tom's voice was lively, rapid, sometimes jerky, often quick in response, and almost always clear-spoken. He made many spontaneous remarks of various kinds, in varied and appropriate tones of voice. He played with words, and became quite imaginative in the things he spoke into WM. He asked questions of I, and volunteered explanations. He occasionally sounded anxious when answering I's questions. In Bs&Bs, his voice was deeper-pitched, stronger, more serious and more confident sounding. He conveyed an even wider range of emotions vocally, showing deep involvement in the task. He still sounded anxious when answering I's questions.

2. Would Tom show immediate, varied and prolonged IMMCur?

As in the individual tasks, Tom's IMMCur was immediate, eager and varied, in both WM and Bs & Bs. He showed the same idiosigneratic style of examining a new object.

3. Would Tom's ideas about causes and conditions, when verbally expressed, be sometimes confused, self-contradictory or inappropriate?

In WM when responding to I, on three occasions, Tom's Id was inappropriate. These errors could have been due to anxiety.

4. Would Tom's manipulative ideas be coherent and systematic; as they were in the individual tasks when Tom was left on his own?

In Bs & Bs, unlike many other children, Tom often spoke about his manipulative ideas, which were coherent and logically connected. As in the earlier tasks, Tom's ideas in Bs & Bs showed evidence of a characteristic style of making detailed variations on each of a set of main ideas. I used caution and restraint when speaking to Tom about his ideas in Bs & Bs; communication did not break down, and the course of Tom's ideas was coherent.

School: S

Child: Jan

Hypothesis-Questions:

1. Would Jan express surprise, puzzlement and wonder consistently and repeatedly?

In WM, Jan was preoccupied with the social situation with respect to the two girls she had picked to work with. She did not notice the puzzling phenomenon for sometime. It seemed to dawn on her, and she

asked how it was done in a manner less open than she had when alone with I. In Bs & Bs, (working with a different partner, with better concentration) she expressed puzzlement many times.

2. Would Jan show a strong interest in finding-out how things worked?

In finding out how the tape recorder worked, Jan asked for guidance at first; but immediately and eagerly set herself to find out how to operate the radio, and also how to operate WM. In Bs & Bs she immediately and spontaneously took on the task of trying to light the bulb and concentrated somewhat steadily on it. In CD, unlike the individual tasks, Jan showed no signs of waiting for permission but manipulated spontaneously, with a strong, evident desire to find out how it worked.

3. Would Jan, when asked, conscientiously and tentatively state possible explanations, and carry out appropriate, objective experiments?

In WM (partly preoccupied with her partners) Jan didn't think she could find out, at first, but then decided that she did. Later, however, their experiments petered out when Jan became more interested in the social aspects of the process. In CD, Jan at first didn't think it possible to get the diver to float part way down, but soon proposed a method, and patiently worked on it. Distracted by her partner's activity, she did not notice that she had succeeded, until I pointed it out. As the CD task went on, Jan got even more interested, active, and productive of ideas.

School: S

Child: Ros

Hypothesis-Questions:

1. Would Ros display anxiety about being observed, and general preoccupation with the adults present?

In WM, Ros did not show concern about O and I watching her, as she had earlier. But Ros seemed to be concerned with being "secretly" recorded, and kept this concern covert. In BP, the task was begun with only the two adults present, and then we moved to the classroom where Ros chose partners. Ros was very preoccupied with O watching her at first, but in the classroom with partners Ros became actively interested in BP and less concerned with the adults. In CD, Ros was again concerned about wearing WM (and about being recorded?), but finally became fully involved. In Bs & Bs, apparently influenced by her partner, Ros became much more responsive to I; but at times became covert or deceptive.

2. Would Ros display the style she displayed in SBG and in RR, of fast, varied, eager, almost impetuous non-verbal ideas - or the style displayed in UR, of repeated, almost unvaried manipulation?

Ros displayed a trace of her impetuous style in WM. In BP, she was repetitive while seemingly preoccupied by the adults' presence but after joining the others she took over a directive role in relation to her partners and in so doing, voluntarily tested all the objects. In CD, her manipulation was goal-directed and highly varied and exploratory; it was energetic but neither repetitive nor impetuous. In Bs&Bs, Ros's manipulation was persistent and eager.

3. Would Ros display the tendency, remarkably displayed in RR, to play with the apparatus as though others present were not there - a quality of almost schizoid withdrawal (for brief periods) into a world of her own?

In WM, Ros at one point disappeared and also turned off WM, thus withdrawing completely. In BP, Ros showed slight but similar tendencies to withdraw or to distance herself from others, for example by suddenly taking a teacher-like role with her partners. In CD, Ros spoke very little to her partner, and seemed to respond to I as though she was willing to say so much but no more. In Bs & Bs, for the first time, she often chatted with her partner and was usually aware of what her partner was doing.

4. Would Ros produce only sketchy ideas if at all?

In WM, the group seemed to avoid even recognizing the puzzling phenomenon, let alone talk about it; but Ros showed some independence in separating herself from the group's avoidance of the question. In BP, proposed physically plausible solutions. In CD, for the first time, Ros produced numerous ideas, and also successfully experimented. In Bs & Bs, Ros's ideation was relatively limited; she seemed to be convinced that one particular operation would work - an idea that she had picked up at some earlier time - in garbled form - and stuck to this idea somewhat rigidly.

Table 3 summarizes the results of testing of hypothesis-questions through observation of small group inquiry in the classroom. Table 3 consists of judgement as to whether each hypothesis-question was confirmed or disconfirmed. Many disconfirmations represented successes of moves to facilitate and improve a child's inquiry; others represented improved inquiry due, presumably, to having friends to work with instead of working alone with the adult (s).

TABLE 3

Confirmation and Disconfirmation of Hypothesis-Questions through Observation of Small-Group Inquiry.

Child	Pet		Sha	Bil		Mic			Tom				Jan			Ros			
Hypothesis-question No.	1	2	1	1	2	1	2	3	1	2	3	4	1	2	3	1	2	3	4
Task																			
Wireless Microphone (WM)	C	-	C	C	D	(D)	D	(C)	D	C	C	-	D	C	D	C(C)		(C)	(C)
Batteries & Bulbs (Bs&Bs)	C	C	C	-	D	D	C	C	D	C	-	C	C	C	-	D	D	D	(C)
Cartesian Diver (CD)	-	-	-	-	-	D	D	D	-	-	-	-	-	C	C	D	D	D	D
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(D)	D	D	D

Code:

C- Confirmed

D- Disconfirmed